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Growing Alfalfa

**U.S. DEPARTMENT
OF AGRICULTURE**

ALFAFA is one of the most important forage crops in the United States.

Alfalfas grown commercially in the United States include regional strains of common alfalfa; the variegated alfalfas—Grimm, Baltic, Cossack, Hardigan, Canadian Variegated (also known as Ontario Variegated) and Ladak; the Turkistan strains—Hardistan and Orestan; and the nonhardy Peruvian alfalfas. The variegated alfalfas are superior to the common in the North, and less hardy varieties are preferable for the South.

Alfalfa succeeds best in a dry climate where water is available for irrigation.

It is best to precede alfalfa for a year or two with some cultivated crop, such as corn, potatoes, or cotton, to free the land from weeds. The ideal seedbed is a well-settled sub-surface with a fine surface that is loose to a depth of 2 inches.

Alfalfa is a heavy consumer of lime; therefore, acid soils require liberal applications to insure success. Liberal applications of phosphoric acid and potash are essential to satisfactory growth if the soil is deficient in these elements, which is usually the case in the eastern half of the United States. In applying lime or powdered chemical fertilizer, the eyes should be protected by dustproof goggles having indirect ventilation.

In the Eastern States inoculation of the soil or seed is required where alfalfa, sweetclover, or bur-clover has not been successfully grown in the past few years.

Alfalfa should always be sown early enough to permit the plants to become well established before winter sets in. The seeding rates per acre generally recommended are 15 to 20 pounds in the East and South, 8 to 12 pounds in the Middle West, 6 to 8 pounds under dry-farming conditions, and 15 pounds for land under irrigation.

In the eastern half of the United States alfalfa is frequently sown in mixtures with timothy, brome grass, or orchard grass.

Stands are maintained longer and the yields are generally larger when cutting is delayed until the plants are well in bloom. Hay of a higher feeding value is obtained from cuttings made at the bud or early bloom stage.

Alfalfa produces seed in paying quantities only when the rainfall is comparatively light. The average yield per acre runs from 2 to 4 bushels.

Bacterial wilt is one of the most serious diseases of alfalfa. The only means of control lies in the use of resistant varieties.

Grasshoppers probably do more damage to alfalfa than any other insect. The most effective means of control is the use of poison baits.

This bulletin is a revision of and supersedes Farmers' Bulletin 1283, How to Grow Alfalfa.

GROWING ALFALFA

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INTRODUCTION

ALFALFA (*Medicago sativa* L.) is a herbaceous perennial legume belonging to the same family as peas, beans, and clover (fig. 1). Its flowers are borne in loose bunches, or racemes, and are of a purplish color. The pods in which the seed is produced are twisted spirally in one or two turns, similar to the shell of a snail. Each pod contains several small kidney-shaped seeds. The stems, which are usually not more than one-eighth of an inch in diameter, are erect and commonly reach a height of 2½ feet. They arise from a semiwoody base known as the crown. The root system is characterized by a distinct taproot, which in permeable soil extends to a considerable depth. The taproot has few to many branch roots. The leaves are in threes, like clover, and are arranged alternately on the stem.

It is generally believed that alfalfa originated in southwestern Asia, though forms from which it might have sprung are found in China and Siberia. Historical accounts indicate that it was first cultivated in Persia. From there it was taken to the Mediterranean countries and finally to North America. The first recorded attempt to grow alfalfa in the United States was made in Georgia in 1736, but it was not until about 1850, when alfalfa was taken to California from Chile, that its rapid extension began in this country.

ACREAGE

Alfalfa is one of the most important forage crops in the United States, exceeding in acreage any of the other perennial crops grown for this purpose with the exception of the combined acreage of timothy and timothy mixed with clover.

Its culture has extended very rapidly since it was first grown successfully in the West. According to the United States census reports the acreage devoted to it practically doubled each 10 years

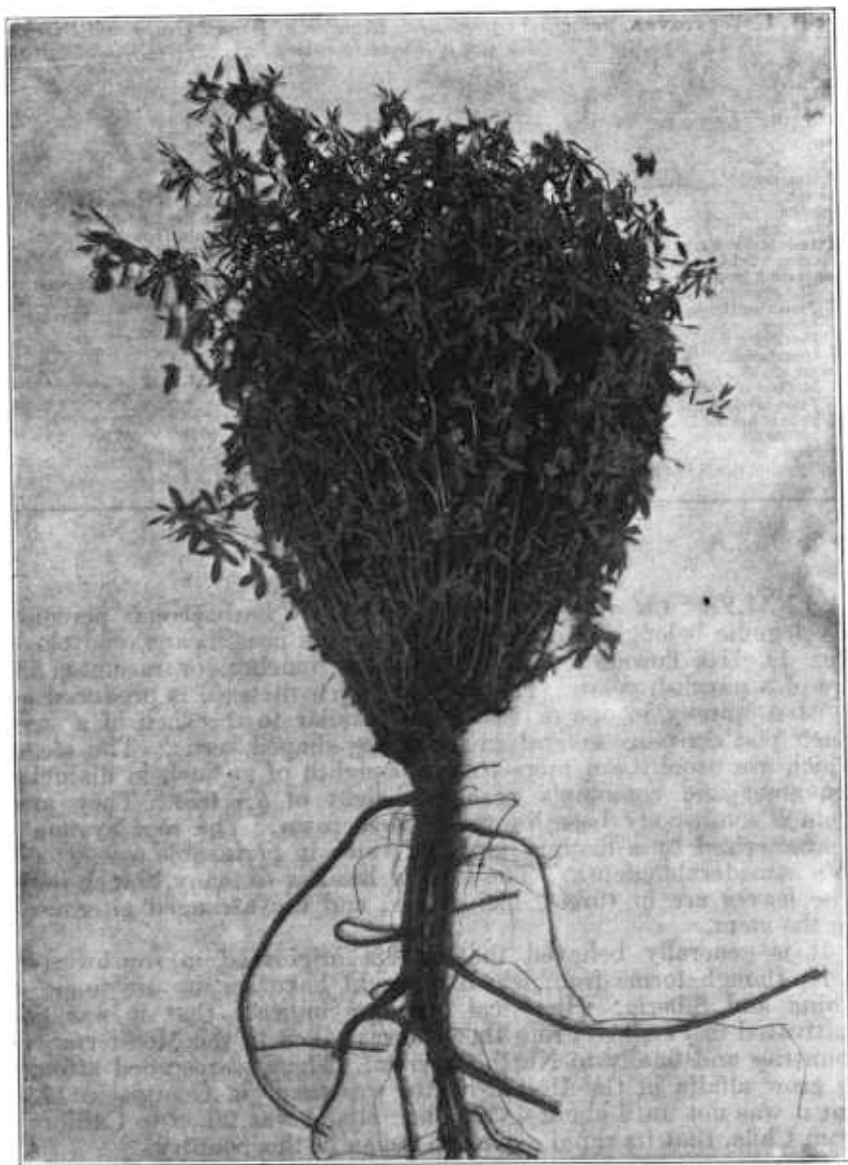


FIGURE 1.—A typical alfalfa plant.

between 1899, when there were 2,094,011 acres, and 1919, when this crop occupied 8,624,811 acres. In 1929 the area in alfalfa amounted to 11,515,811 acres, which represents an increase of 33.5 percent over the 1919 acreage.

According to the United States Department of Agriculture, Agricultural Statistics for 1940, there were 13,494,000 acres of alfalfa in the United States in 1939, an increase of about 17 percent over the number reported in 1929. The proportion of the acreage east of the Mississippi River increased from about 1 percent in 1899 to a little more than 17 percent in 1929, and about 35 percent in 1939. Between 1929 and 1939 the acreage west of the Mississippi River actually decreased about 8 percent, whereas east of the river during this period the acreage more than doubled. Although the acreage south of the Tennessee-Kentucky line increased appreciably it still remained relatively unimportant. The big increase in acreage east of the Mississippi River was due to a large extent to the decided increases in Wisconsin, Michigan, Indiana, Illinois, Kentucky, Ohio, New York, and Pennsylvania. This change was the result in part of the drought and the spread of bacterial wilt in the West and in part of the high freight rates which increased the price of hay in the East to such an extent that more attention was given to local production. In 1939 Minnesota led all the States in acreage of alfalfa, followed closely by Wisconsin and Michigan, each State producing a little more than a million acres. Other States, in order of acreage, included Iowa, Idaho, California, Montana, Colorado, Nebraska, and Ohio, each with more than half a million acres. Kansas with 410,000 acres had fallen from first place in 1919 to seventh place in 1929, and eleventh place in 1939. The total production of alfalfa hay for the United States in 1939 was 27,035,000 tons, the average yield per acre being 2 tons. This ranged for the different States from approximately 1 ton in the Dakotas to 4.3 tons in California. In general, the highest average yields were obtained in those States where most of the crop was grown under irrigation.

VARIETIES

The commercial varieties of alfalfa in the United States consist of the regional strains of common alfalfa; the variegated group, including the varieties Grimm, Cossack, Baltic, Canadian Variegated (also known as Ontario Variegated), Hardigan, and Ladak; the Turkistan group, including commercial Turkistan, Hardistan, and Orestan; and the nonhardy Peruvian alfalfas.

Common alfalfa includes the greater part of the alfalfa grown in this country. Much of it traces originally to seed that was brought to California from Chile about 1850, and for this reason is frequently referred to in Arizona and California as Chilean alfalfa. The seed from the various States or sections is usually designated by the name of the State in which it is grown. Common alfalfa varies considerably in hardiness and other characteristics, depending upon the conditions under which it has been produced. When it has been grown for several seed generations in the North it has acquired characteristics that render it more resistant to winter-killing than when it is grown southward. In purchasing seed, therefore, an effort should be made to procure it from a source where the winters approximate in severity those where the seed is to be sown. In the southeastern one-fourth of the United States, seed of common alfalfa grown in Kansas and at similar latitudes generally has given larger yields of hay and for this reason is usually more desirable than seed

produced in the Northern States. All common alfalfas tested have been susceptible to bacterial wilt.

The alfalfas of the variegated group are generally recognized as being hardier than the common alfalfas. They are the result of a natural cross between the well-known purple-flowered alfalfa (*Medicago sativa*) and the yellow-flowered species (*M. falcata*). They owe their superior hardiness in part to the presence of the yellow-flower blood in their ancestry and in part to the natural selection that has taken place under the severe climatic conditions to which they have been subjected. The variegated alfalfas are recommended for the Northern States, where the winters are severe. Southward, where winter-killing is not a factor to be considered, certain strains of common alfalfa will ordinarily give somewhat larger yields, and the seed is usually cheaper.

Grimm alfalfa is the best known and most extensively grown variety in the variegated group. It was brought to this country from Germany in 1857 by Wendelin Grimm and was grown for several years in Minnesota before the attention of the public was called to its superior hardiness. Owing to its cold-resistance, its culture is confined pretty largely to the northern half of the United States, where the winters are severe. Because of its susceptibility to bacterial wilt its use has declined where this disease is destructive.

Cossack alfalfa was introduced into the United States from Russia through the efforts of the United States Department of Agriculture in 1907. In tests this variety has given results comparable to Grimm alfalfa, but it is grown on a much smaller scale. It appears to be slightly less susceptible to wilt than Grimm.

Baltic alfalfa takes its name from Baltic, S. Dak., near which town it was grown for several years. In yield and adaptability this variety compares favorably with Grimm but has not given evidence of being superior. It has not been extensively grown, and the seed supply is rather limited. Like Grimm it is susceptible to wilt.

Canadian Variegated alfalfa is similar in appearance and adaptation to Grimm alfalfa. In the northern humid States it has given results comparable to Grimm, but in tests in the northern Great Plains it has not appeared quite so hardy nor as productive. Practically all of the seed sown in the United States is produced in Canada. Under regulations promulgated in pursuance of the Federal Seed Act, 1 percent of each lot or shipment must be stained violet before it is permitted entry into this country. Canadian Variegated alfalfa is susceptible to bacterial wilt.

Hardigan alfalfa is a selection from Baltic made by the Michigan Agricultural Experiment Station for superior hay and seed production. In some tests in the humid Eastern States it has been somewhat more productive than other variegated alfalfas, but it is not superior to them in cold resistance. It is susceptible to bacterial wilt.

Ladak alfalfa was imported through the efforts of the United States Department of Agriculture from northern India in 1910. It has given excellent results in the northern Great Plains. It is hardier and more drought-resistant than other alfalfas of the variegated group and has the further advantage of being somewhat resistant to bacterial wilt.

Turkistan alfalfa was introduced into the United States in 1898, and at one time most of the imported seed came from Turkistan. In

recent years, however, there have been no commercial importations of Turkistan seed. Turkistan alfalfas vary in their reaction to cold and bacterial wilt, but recent tests indicate that seed from the most important seed-producing districts in that country is generally equal or superior to Grimm alfalfa in hardiness and is also resistant to bacterial wilt. In numerous tests in various parts of the United States Turkistan alfalfa has usually been less productive than some of our domestic alfalfas. It has given fairly good results in the central and northern Great Plains and may be used to advantage in that area where wilt is prevalent, especially if the grower desires to retain the stands several years.

In the East and South, however, Turkistan alfalfa has given very unsatisfactory results owing to its tendency to become dormant early in the fall and its susceptibility to yellowing and to certain leaf diseases that result in the shedding of many of the leaves before the alfalfa has reached the most desirable stage for harvesting. Under regulations governing the enforcement of the Federal Seed Act, 10 percent of Turkistan alfalfa seed must be stained red before it is permitted entry.

Hardistan is the name given by the Nebraska College of Agriculture to an alfalfa that is undoubtedly of Turkistan origin and that first attracted attention by its apparent resistance to wilt and cold. It is very similar to some of the better commercial importations from Turkistan as regards resistance to cold and wilt, susceptibility to leaf diseases, tendency to early dormancy, and productivity. Although the variety is promising where wilt is prevalent in the upper Mississippi and Missouri Valleys, preliminary tests indicate that it is not likely to prove more satisfactory in the East and South than most of the commercial lots from Turkistan. The seed supply is at present very limited, but efforts are being made to increase the seed for sowing in areas where wilt is destructive.

Orestan is the name applied to a Turkistan alfalfa that has been increased from an introduction in 1929. In early tests in eastern Oregon this alfalfa appeared to be somewhat superior to other Turkistan introductions made at that time. It appears to be equal in wilt resistance to the best alfalfas from that source but has given no indication of being better adapted to eastern humid conditions. The seed is being increased, mainly in Oregon, but the supply is still rather limited.

Peruvian alfalfa is the least hardy and most rapid growing of our commercial varieties. It was introduced into the United States from Peru in 1899. It seldom survives the winters where the temperature falls below 10° F. and is therefore suited only to the extreme South and Southwest. Where it survives the winters, Peruvian alfalfa gives somewhat larger yields than most other varieties. Two strains of Peruvian alfalfa are recognized, the smooth-leaved Peruvian and the hairy Peruvian. The latter usually produces somewhat heavier yields of hay than the former and is therefore preferable. A more detailed discussion of these alfalfas, as well as of others of less importance, will be found in Farmers' Bulletin 1731, entitled "Alfalfa Varieties in the United States."

New strains of alfalfa believed to be superior in resistance to bacterial wilt and more desirable in other respects than any of the commercial alfalfas have resulted from an intensive breeding program con-

ducted by the Division of Forage Crops and Diseases of the United States Department of Agriculture, in cooperation with several State experiment stations. Attempts are now being made to increase the seed supply of the most promising lines. If, after further testing, these alfalfas prove as superior as indicated by earlier results, they will be released commercially, probably in 2 or 3 years.

SEED

Before buying alfalfa seed there are three points upon which the purchaser should have information: (1) The name of the variety, (2) the section of the country in which it was produced, and (3) the quality of the seed with regard to germination and purity. Unfortunately, it is not possible to distinguish between varieties or strains of alfalfa by the appearance of the seed, and at times, owing to misrepresentation, intentional or otherwise, farmers have had more or less difficulty in obtaining seed of the alfalfa desired. This situation, however, has been remedied to a considerable extent and now, by observing proper precautions, the grower may be reasonably sure of the variety and origin of the seed he purchases.

State seed laws and the Federal Seed Act require that seed be labeled, and the farmer purchasing seed should observe the information given on the label.

Several State agencies register and certify alfalfa seed as to variety, each package bearing a tag to this effect. Varieties so registered and certified include Grimm, Baltic, Cossack, Ladak, Hardigan, and in some States seed from fields of common alfalfa of long standing.

The Federal Seed Act requires that certain percentages of all lots of imported seed be stained before it is permitted to enter the United States, the color depending upon the origin or adaptability of the seed as determined by tests conducted in this country. As seed from Canada has been found suitable for growing in the United States, 1 percent of it is stained violet. Ten percent of seed from all other foreign sources is stained red, except that from South America, 10 percent of which is stained orange-red. Ten percent of imported seed is stained red if the origin is such as requires staining different colors or if the seed is of a foreign origin and has been commingled with seed grown in the United States.

The viability of the seed, or its ability to germinate, is ordinarily indicated in its appearance. Plump seeds of a bright olive-green color almost invariably germinate well, whereas shriveled seeds or seeds that are of a brownish color usually germinate poorly. Alfalfa seed turns reddish brown with age, and although some viable seed may possess this color, such seed should not be purchased without a germination test, even if it is offered at a price materially less than that asked for seed of a fresh olive-green color. When a germination test is desired it can be made by placing 100 seeds between cloths or blotting paper and keeping them moist and at a temperature of about 70° F. After 5 or 6 days most of the readily viable seeds will have sprouted. There will be some, however, that will remain hard, especially if they are of the variegated varieties. Many of these

hard seeds will grow when put in the ground, and therefore they should be considered in estimating the percentage of germination.

With regard to the purity of alfalfa seed, every farmer should be able to recognize readily the most important weed seeds and other impurities that are commonly found in it. Seed to be acceptable should contain not more than 2 percent of impurities. At the present time there is almost no attempt to adulterate alfalfa seed in this country, but every lot should be carefully examined for seed of noxious weeds before it is purchased.

It is very desirable that every farmer acquaint himself with the impurities and noxious-weed seeds that alfalfa seed commonly contains, in order that there may be no serious delay in purchasing seed for sowing.

Reports on purity and germination may be obtained by submitting samples of seed to the State experiment station seed laboratories or to commercial laboratories recommended by the State experiment station.

CLIMATIC AND SOIL RELATIONS

The wide distribution of alfalfa in the world indicates a remarkable adaptability to climate and soil. Although the crop requires considerable moisture to produce profitable yields of hay or pasture, it does best in a relatively dry atmosphere where water is available for irrigation. It is not as well adapted to humid conditions. In the United States it succeeds at altitudes ranging from below sea level in the Imperial Valley, Calif., to 8,000 feet in the mountains of Colorado. It withstands hot weather well but is seriously affected by the cold weather of winter and early spring. To what extent extremely low temperatures alone are responsible for the death of alfalfa plants during the winter is not known, but this, together with other winter conditions, commonly results in high mortality. On poorly drained clay soils alternate freezing and thawing, such as occur in many sections, frequently do much damage to alfalfa by heaving the plants out of the soil and incidentally breaking the roots 6 or more inches from the crown.

Deep loams with open porous subsoils are undoubtedly best for alfalfa, but where other conditions are favorable the plant has a very wide range of adaptation insofar as soils are concerned. On account of the deep, penetrating character of its root system alfalfa does not thrive on a soil that has an impervious subsoil, hardpan, or bed-rock near the surface. Instances have been observed, however, where it made satisfactory growth on soils underlain at 18 inches by limestone ledges.

Good surface drainage and underdrainage are both necessary if alfalfa is to thrive. During the growing season complete submergence for 24 or 48 hours may do considerable injury, but when the plants are dormant they may remain under water several days with no serious damage. The formation of ice sheets on alfalfa fields during the winter months may result disastrously. It is sometimes possible to reduce the amount of damage to a minimum by breaking up the ice sheets with a disk or in a similar manner. Alfalfa seldom succeeds if the water table comes close to the surface, especially if the level of the water table fluctuates considerably.

In the eastern part of the United States rich river bottoms and soils of limestone origin are best suited to alfalfa, provided they are well drained, although with proper soil amendments the crop is grown successfully on a wide variety of soils. On strongly alkali soils, such as are frequently found in the West, alfalfa makes little or no growth.

CHOOSING A FIELD FOR ALFALFA

In selecting land for alfalfa careful consideration should be given to the texture of the soil, its productivity, and drainage. Where possible, very sandy or very compact soils should be avoided. The character of the subsoil requires special attention. It is a waste of time and money to attempt to grow alfalfa on land that is underlain at shallow depths by hardpan or other impervious strata. The soil auger is of considerable assistance in determining the character of the soil and subsoil and should be used freely.

The most productive soils on the farm should be selected for alfalfa. It is practically useless to attempt to grow the crop on lands that are nonproductive with the idea of building them up, as is often done. Where good drainage does not exist naturally, it must be supplied by artificial means before alfalfa can be expected to succeed. Tile drains placed 3 feet below the surface will ordinarily lower the water table sufficiently to insure the satisfactory growth of alfalfa, other conditions being favorable. Complaints are occasionally received of tile drains that carry water continuously being clogged by alfalfa roots, but this occurs so seldom that it need be given little consideration.

PREPARATION FOR ALFALFA

THE PRECEDING CROP

Alfalfa may be successfully grown after almost any crop provided proper attention is given to the preparation of the soil after the preceding crop has been removed. In deciding upon the preceding crop, however, one should be chosen that fits best into the particular system of farming and at the same time leaves the land in good condition for alfalfa. Due consideration also should be given to the time available for preparing the seedbed for alfalfa after the preceding crop has been harvested. As the young alfalfa plants are very tender and are likely to be killed by weeds during their early stages of growth, it is best to precede the alfalfa for 1 or 2 years with some cultivated crop. Corn or potatoes in the North and corn, tobacco, or cotton in the South serve this purpose admirably. In the Southern States crimson clover or rye and vetch may be sown after the removal of any one of these cultivated crops. The cover crop should be plowed under or cut for hay the following season and the land prepared for alfalfa. Where late summer or early fall sowing is practiced, canning peas, early potatoes, and early sweet corn leave the land in excellent shape, and little further preparation is required. The heavy application of fertilizers that these crops require in many parts of the country will usually suffice for alfalfa. Except in the extreme North, small-grain stubble may usually be worked up in time for late-summer sowing provided the land has

previously been treated so as to destroy the weeds. The chief objection to such a practice is the possible lack of moisture in the soil, due to the demands of the grain crop and the hot weather of summer. Crops that smother the weeds, such as cowpeas, may be used to precede alfalfa to good advantage. In the East it is not usually advisable to sow alfalfa on sod land, but in the Great Plains area this is done with a considerable degree of success.

PREPARING THE SEEDBED

The tender nature of the young alfalfa plants requires that the soil be in excellent tilth at sowing time. Many of the failures to obtain a good stand may be traced directly to a poorly prepared seedbed. A desirable condition is a well-settled subsurface and a fine surface that is loose to a depth of at least 2 inches. Such a condition is best obtained by plowing the land in the fall, disking in the spring, and harrowing occasionally to keep down the weeds until sowing time. Where fall plowing is not practicable the land should be broken at least several weeks in advance of sowing. Meantime the soil should be disked and harrowed at frequent intervals to settle the seedbed. The cultipacker will be of considerable assistance in getting the soil into the desired condition. In the northeastern one-fourth of the United States, where alfalfa is sown the same season after the removal of a crop of small grain, it is generally better to avoid plowing except on the heavier soils, as there is seldom sufficient time for the soil to become properly settled before sowing. If such land is well prepared for the grain crop, a thorough disking followed by one or two harrowings will ordinarily leave the seedbed in fairly good condition. Land that has been in early potatoes, peas, or sweet corn can usually be prepared satisfactorily by removing the vines or cornstalks and harrowing. In preparing clover sod for alfalfa the land should be plowed as soon as the crop is removed and disked and harrowed until a firm fine seedbed is obtained. The preparation of sod land may be facilitated by cutting the sod with a disk before plowing. In semiarid regions summer fallowing is often practiced to insure satisfactory moisture conditions for the seedlings the following spring. This method is also effective in any section for ridding the ground of weeds, but it involves considerable expense. Any seedbed-preparation practices that might lead to soil blowing, especially in certain parts of the Great Plains region, should be avoided.

LIMING

Alfalfa stands out among legumes as a heavy consumer of lime. It is necessary not only to have enough to neutralize the soil but also an excess for the actual use of the plant. If there is any doubt about the need for lime, the question should be definitely settled before time and money are wasted in an effort to get alfalfa started. Litmus paper, which can be obtained at any drug store, is a simple though not always an infallible test of the need for lime. Because the lime requirements of soils vary so widely, the prospective grower of alfalfa would do well to seek more exact advice on the probable need for lime from his county agricultural agent or State agricultural experiment station.

In the humid East it is safe to assume that all soils except those of limestone origin will require lime for alfalfa. Even limestone soils are often acid at the surface, and lime must be applied before alfalfa will succeed on them. Limestone soils that do not require additional lime occur in the black belt of Alabama and Mississippi and near Syracuse, N. Y., whereas limestone soils that need lime are found in the Shenandoah Valley. With the exception of the soils of the Pacific slope of the northwestern part of the United States, which have a high lime requirement, most of the soils west of the ninety-fifth meridian do not require liming for alfalfa.

There are several different forms of lime on the market, such as burned lime, slaked or hydrated lime, ground limestone, oyster shells, and marls. Burned or hydrated lime may give quicker results, but finely ground limestone will eventually bring the same benefit. For correcting acidity, 1 ton of burned lime is equivalent to $1\frac{1}{2}$ tons of slaked lime or 2 tons of ground limestone. Marls vary so in composition that a chemical analysis of the material from each source is necessary to determine the percentage of calcium oxide.

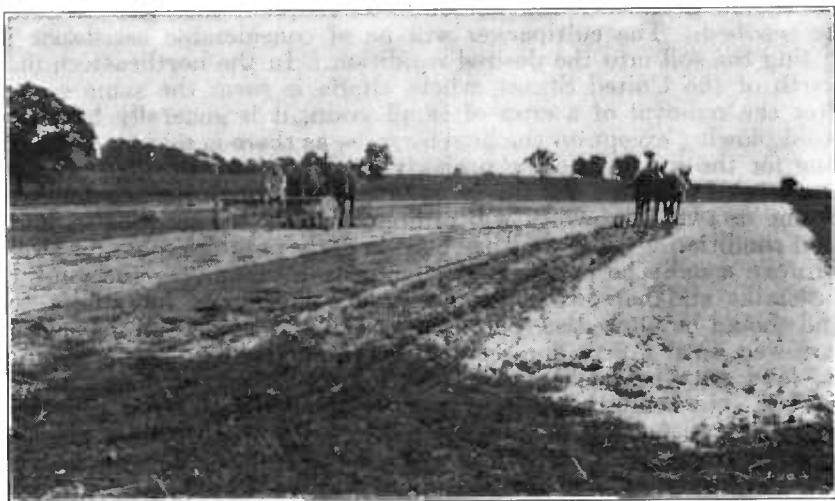


FIGURE 2.—Liming for alfalfa.

When lime is being handled or applied, the eyes should be protected by dustproof goggles having indirect ventilation.

The quantity of lime required depends upon the soil, but ordinarily not less than 1 ton of burned lime per acre or the equivalent of this in other forms of lime is needed. In some cases much larger quantities are required.

The farmer should use whichever is cheapest, based upon the relative proportion of calcium oxide, which is the essential element so far as correcting acidity is concerned. Where the consumer pays the freight he should bear in mind that he not only will have to pay such charges on twice as much ground limestone as on burned lime but also will have the additional expense of hauling and spreading 2 tons of the former to 1 of the latter to get the same benefit.

When practicable it is well to apply part of the lime the season previous to sowing the alfalfa. This is particularly advisable where

ground limestone or oyster shells are used, as the lime in this form is not so readily available as is the burned lime. Where it is not convenient to apply any part of the lime the preceding season, it may be applied after plowing, preferably 3 or 4 weeks before the seed is to be sown, and thoroughly incorporated with the soil. The lime may be applied with a manure spreader, a fertilizer distributor, a lime distributor, or by hand (fig. 2). Any method that spreads the lime evenly and at low cost is satisfactory. Top dressing an alfalfa stand with lime is not recommended.

FERTILIZING

Alfalfa, being a heavy feeder, requires an abundance of available plant food in the soil for its best growth. On most of the soils east of the ninety-fifth meridian alfalfa responds to some sort of fertilizer treatment. The greatest need seems to be for phosphoric acid, and liberal applications will in most cases yield profitable returns.

Potash is an essential element, and light applications are beneficial on some clay soils and most sandy soils. Alfalfa requires some nitrogen in the soil for its early growth, but after it is once established, other conditions being favorable, it is able to procure most of its supply from the air by means of the bacteria in the nodules on the roots.

Good barnyard manure furnishes not only humus but also other plant food required by alfalfa and for this reason is one of the most satisfactory fertilizers. It may be applied to the previous crop; it may be applied in the autumn and plowed under prior to sowing alfalfa; or it may be turned under in the spring where fall plowing is not practicable. It is always well to apply the manure long enough in advance so that it will become well incorporated with the soil. Where the quantity of barnyard manure is limited it may be made to go farther by using some superphosphate (acid phosphate) in connection with it. Where it is not available the humus may be supplied by plowing under some green-manure crop and by applying commercial fertilizers. In the North such crops as rye, vetch, and Canada field peas may be used. Farther south bur-clover, crimson clover, soybeans, and cowpeas answer the purpose admirably.

If commercial fertilizers are used they should consist largely of superphosphate, about 300 to 500 pounds per acre of 16 percent superphosphate, and 75 to 100 pounds of muriate of potash. In addition, 50 to 75 pounds of nitrate of soda on eastern and southern Coastal Plain soils is often helpful in giving the alfalfa a start. The proportion of potash may be increased on sandy soils and decreased on clay soils.

Other forms of fertilizer may be used to supply the elements needed by alfalfa, such as cottonseed meal in the place of nitrate of soda and other materials which furnish phosphoric acid. Generally speaking, raw-rock phosphate has not given as satisfactory results as superphosphate, as it is much slower in acting than after it has been treated with acid. Light applications of 20 to 40 pounds per acre of borax have been beneficial on certain soils. Heavy applications may be injurious. Most of the experiments that have been conducted in the East indicate that alfalfa is not appreciably benefited by applications of flowers of sulfur.

Flowers of sulfur is irritating to the eyes and nasal passages and will cause skin irritation if it comes in contact with perspiration on the skin, such as under the arms. Dusttight goggles with indirect ventilation and an approved respirator should be used. A full face-piece respirator can be obtained that protects both the eyes and respiratory organs. Proper clothing should be worn to protect the parts of the body where perspiration collects.

West of the ninety-fifth meridian many of the soils do not require any special fertilizer treatment for alfalfa. However, there seem to be an increasing number of cases where land that has given good yields of alfalfa for several years when reseeded failed for some reason to give satisfactory results, indicating a decrease in certain plant-food elements. In such cases the use of superphosphate has often proved highly beneficial. On some of the lands of the Pacific Northwest, particularly in Oregon, applications of 50 to 100 pounds per acre of flowers of sulfur have given greatly increased yields. On the same soils gypsum has increased the yields of alfalfa. On certain soils in this region light applications of borax have resulted in greatly increased yields. In many cases, however, these fertilizers, if they produce any increase in the growth of alfalfa, do not give sufficient increase to justify the extra labor and money involved, and the farmer is advised to avoid any great expense in connection with their use until he has first determined on a small scale whether they will produce any appreciable benefit.

INOCULATION

With the exception of those of the Pacific-coast region of the northwestern part of the United States, most of the soils west of the ninety-fifth meridian are naturally supplied with proper bacteria for inoculating alfalfa. In the eastern part of the country, however, where the soil conditions are less favorable to the growth of nitrogen-fixing bacteria, it is nearly always necessary to supply them at the time of sowing, where alfalfa is grown for the first time. Fields that within the past few years have grown alfalfa, sweetclover, bur-clover, or black medic successfully will not ordinarily need further inoculation for alfalfa.

The surest way of getting a new stand of alfalfa well inoculated is to scatter soil from a successful alfalfa field or from the roots of sweetclover or bur-clover plants. In the past the general recommendation has been to use 250 to 500 pounds of soil per acre, the application of which is rather tedious and expensive. In some experiments equal quantities of soil and seed have given good results. This mixture may be sown broadcast or drilled. If it is drilled in, only finely sifted soil should be used, and as the soil particles are inclined to work toward the bottom of the drill box it may be necessary to add a little occasionally or keep the seed well stirred. Moistening the seed with water to which has been added a little glue and mixing a small quantity of soil with the seed, although not always successful, has in many cases resulted in satisfactory inoculation.

Inoculation is also accomplished by means of artificial cultures that are put out by most of the State agricultural experiment stations and several commercial firms. Instructions for use accompany these cultures.

The practice of sowing a small quantity of alfalfa with the regular sowing of clover or other hay-crop seed has in some cases apparently been the means of introducing sufficient bacteria for inoculating the succeeding crop of alfalfa.

Investigations indicate that a single inoculation should be adequate for many years, provided the soil is kept well supplied with organic matter and lime, even though alfalfa or sweetclover is not grown on the land. If the soil is allowed to become strongly acid or to lose a large part of its vegetable matter the bacteria decrease very rapidly.

SOWING ALFALFA

METHOD OF SOWING

The method of sowing varies considerably in different sections. It may be done with a grain drill with a seeder attachment or with an alfalfa drill (fig. 3), or the seed may be broadcast with a hand seeder, a wheelbarrow seeder, or by hand and covered with a light harrow, a weeder, or a brush drag. If the seed is drilled a somewhat



FIGURE 3.—An alfalfa drill.

lighter rate is required than if it is broadcast, as better conditions are provided for germination. In order to insure a more even stand, it is best to sow half the seed one way across the field and the other half at right angles to the first sowing. The depth to which the seed should be covered depends on the character and condition of the soil. On heavy soil one-half inch is usually sufficient, but on sandy or dry soils a somewhat greater depth is usually necessary to insure getting the seed in contact with moisture.

The use of a cultipacker before sowing is of considerable assistance in making conditions favorable for the germination of the seed. Good results have been obtained by first running the cultipacker over the land, then sowing the seed, and finally harrowing lightly or cultipacking again at right angles to the first cultivation.

Good results are occasionally reported from broadcasting on honey-combed ground during late winter or early spring. In a few instances

sowing in corn at the last cultivation has given good stands, and yet it can hardly be termed a safe practice. With abundant rainfall and ideal soil conditions this method sometimes gives good results. The presence of stubble may be more or less troublesome in the first cutting the next season unless the corn has been cut very close to the ground. Sowing in small-grain stubble is advised where soil blowing is troublesome.

TIME OF SOWING

The general principle underlying the time of sowing is to get the seed in the ground as far as possible in advance of what promises to be the most trying season for the young plants. In the northern half of the United States, where rainfall is abundant and soil conditions are suited to alfalfa, seed is often sown in the early spring with a nurse crop. When sown alone, late spring or early summer sowing is generally best, as this gives an opportunity for preparing a good seedbed and at the same time permits the plants to become thoroughly established before cold weather sets in. In the Southeast the most favorable time varies from the middle of August in the latitude of Washington to late October or early November along the Gulf coast. February and March sowings are sometimes successful in the extreme South, but late-spring and early-summer sowings are likely to be crowded out by the weeds.

In the northern part of the dry-farming area of the Great Plains it is almost necessary to sow seed as early in the spring as the land can be put into shape, as moisture conditions are most favorable at that time. During the summer the soil usually is so dry that the young plants are not able to make sufficient growth to withstand the cold winters. In the southern part of this area, however, good stands are often obtained from late summer and early fall sowings.

In the irrigated districts of the Southwest, October is the best month for sowing alfalfa, although good stands are obtained almost any time between October 1 and April 15. The hot summer months constitute the most unfavorable period. In the North spring sowings are most satisfactory, although good stands have been obtained when the seed was sown in grain stubble in the late summer or early fall.

RATE OF SOWING

A good stand of alfalfa is highly important from the outset. The quantity of seed necessary to insure a sufficient number of plants per acre varies in different parts of the country and is directly dependent upon the condition of the seedbed. If every seed should grow, 1 or 2 pounds per acre would be ample, but some of them are not viable, and others are covered too deeply or fall in dry soil and fail to germinate. Furthermore, many plants that start to grow succumb in the seedling stage, from one cause or another. For these reasons it is always advisable to sow a larger quantity of seed than would be necessary under ideal conditions. Most State experiment stations east of the Appalachian Mountains recommend 15 to 20 pounds of seed per acre although several, particularly those in the Southeast, still recommend 20 to 30 pounds per acre. Carefully conducted experimental tests indicate that little is to be gained by these heavier rates of seeding. If the seedbed preparation has not been such as to give satisfactory stands with 12 to 15 pounds per acre, it is doubtful

if the stand will be improved materially by doubling the rate. In the Corn Belt seeding at the rate of 10 to 15 pounds per acre is advised by most State experiment stations though 8 to 10 pounds have been shown to produce satisfactory stands on a well-prepared seedbed. Under dry-farming conditions in the Great Plains and Western States 6 to 8 pounds per acre is recommended for hay and one-half of this amount for seed production when drilled or sown broadcast. In rows 1 to 3 pounds per acre is ample, depending upon the moisture supply, the lower rate being better where limited moisture is available. Under irrigation most State experiment stations advise using 12 to 20 pounds of seed per acre and occasionally more for hay or pasture, and about one-half this amount for drilled or broadcast seeding intended for seed production.

ALFALFA MIXTURES

In the West where environmental conditions are naturally suited to the production of alfalfa, the crop is sown in mixture with grass to a very limited extent, if it is intended mainly for the production of hay or seed. Under such conditions mixtures usually produce little or no more than alfalfa alone. If the crop is to be used primarily for grazing, alfalfa is often sown in mixture with some adapted grass. North of the Kansas-Oklahoma line brome grass is most generally used for this purpose, although crested wheatgrass and slender wheatgrass are used to a limited extent. In the Northwest, where alfalfa is grown under irrigation and at high altitudes, timothy or brome grass, or both, are often sown with alfalfa, clover sometimes being added to the mixture. In the southern Great Plains alfalfa is usually sown alone. In the irrigated valleys of the Southwest, barley is frequently sown in the fall in established stands of alfalfa, such fields being grazed during the winter and early spring. In thin stands of alfalfa, Sudan grass is sometimes sown in the spring or early summer to increase the yields. In the Corn Belt it is a rather common practice to sow timothy or brome grass with alfalfa, particularly on soils that are not well adapted to alfalfa. Under most conditions the Ohio Experiment Station has found a mixture of timothy, clover, and alfalfa more productive and preferable to alfalfa alone. In the Northeast a similar mixture is being used to a considerable extent under less favorable conditions. In the Southeast alfalfa is usually sown alone.

NURSE CROPS

If a nurse crop can be used without danger of decreasing the chance of securing a stand of alfalfa, it is desirable, as it gives some return from the land while alfalfa is becoming established. The chief objections to a nurse crop are that it draws rather heavily on the moisture supply of the soil, and as it is harvested at a hot time of the year the sudden change from the shade offered by it to the bright sun is likely to prove injurious to the alfalfa seedlings.

The practice of making early-spring seedings with any one of the small grains where conditions are favorable for alfalfa is becoming more general, and satisfactory stands usually result. The small grains are probably no harder on the alfalfa than the heavy growth of weeds that generally results in early seedings without a nurse crop. Any one of the spring grains, preferably an early-maturing

variety, may be used as a nurse crop. Such evidence as is available indicates that flax, in regions adapted to this crop, is one of the safest nurse crops for alfalfa. It is generally advisable to sow the grain at about one-half the normal rate and harvest it as soon as it shows evidence of injuring the alfalfa. Good results have also been reported from sowing alfalfa with winter wheat sown in the spring. In parts of the Northeast satisfactory stands are obtained when alfalfa is sown with canning peas, as they are harvested early and are less injurious to the young seedlings than are the small grains. Alfalfa is sometimes sown in the spring in winter wheat or rye, but the results from sowing in such established crops are less likely to be satisfactory. Wheat or rye ground is often rather compact, and as alfalfa seed must be covered to insure a satisfactory stand it is necessary to loosen the soil before drilling or broadcasting alfalfa seed.

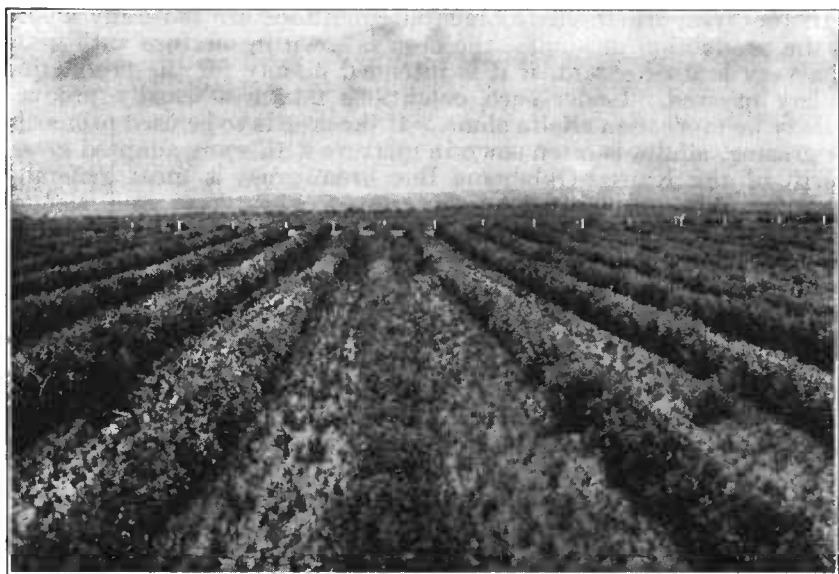


FIGURE 4.—Alfalfa in cultivated rows.

In some cases it is advisable to follow with a harrow after seeding to insure better covering.

In the dry-farming regions, where moisture is the limiting factor, the use of a nurse crop is almost sure to prove disastrous except in seasons of abundant rainfall. Under irrigation the percentage of successful stands with a nurse crop runs somewhat higher. The practice is commonly advised in spring sowings in the northern irrigated districts, but farther south it is considered a better practice to sow the alfalfa alone. The nurse crop is seldom used with late summer or fall-sown alfalfa, except occasionally in the Southwest.

GROWING ALFALFA IN ROWS

At one time it was believed that growing alfalfa in cultivated rows would be advantageous in regions of limited rainfall (fig. 4). It was hoped that in such regions it would be possible to produce

satisfactory yields of hay and seed in this way. Farmers, as well as investigators of the United States Department of Agriculture and several State experiment stations, have given the method a thorough trial. The results of these tests indicate that where rainfall is not sufficient to produce profitable yields of hay in broadcast or close-drilled fields it is likewise insufficient for alfalfa in cultivated rows. Where rainfall is very limited the yield from rows is somewhat greater than that from the close-drilled fields, but not enough larger to justify the extra expense involved. The cultivation necessary to keep down weeds adds considerably to the expense of growing the crop. Moreover, the hay is of a poorer quality, as it is dusty and contains many small clods of dirt.

With the limited moisture available under semiarid conditions, alfalfa in rows usually produces a higher average yield of seed than when drilled or sown broadcast. This method of producing seed is commonly practiced under dry-land conditions.

INSTRUCTIONS FOR GROWING ALFALFA

MICHIGAN, WISCONSIN, MINNESOTA, NEW YORK, AND THE NEW ENGLAND STATES

In Michigan, Wisconsin, Minnesota, New York, and the New England States the following practices are observed in the growing of alfalfa.

Attention is given to the need for lime, fertilizer, and inoculation, as mentioned on pages 9-13. Land that is intended for alfalfa should be in some cultivated crop, such as corn or potatoes, for 1 or 2 years prior to being sown in alfalfa. The ideal seedbed is obtained by plowing in the fall and completing preparation in the spring. On some soils that have been in a clean-cultivated crop the previous season a good seedbed can be prepared by disking and harrowing in the spring without the necessity of fall plowing. Under favorable conditions the practice of sowing alfalfa seed in the spring with a small grain as a nurse crop results in good stands. An early-maturing variety of grain is preferable and should be sown at the rate of about 1 bushel per acre. In order to conserve moisture it is sometimes advisable to cut the grain for hay just after it has headed. If the grain lodges it should be removed early; otherwise it may smother the alfalfa. Canning peas make an excellent nurse crop, as they are harvested early.

Successful stands are also obtained from sowing the seed alone in June or early July, but when this is done no return is obtained from the land the first year. For this reason most farmers prefer to chance sowing later, after some such crop as early potatoes or an early truck vegetable has been removed, as the land requires little preparation for alfalfa provided the vegetable crop has been well cultivated. It is seldom safe to sow alfalfa after a crop of small grain has been removed as there is barely time for the alfalfa to become thoroughly established before cold weather, and the moisture supply may be limited owing to the demands of the preceding crop. Seedings made later than the middle of August are not dependable, as the alfalfa may not make sufficient growth to withstand the winter.

On land that is well adapted to alfalfa 10 to 12 pounds per acre of clean seed that germinates 90 percent is sufficient, although several New England States recommended 15 to 20 pounds.

**OHIO, INDIANA, ILLINOIS, IOWA, MISSOURI, KENTUCKY, PENNSYLVANIA,
NORTHERN NEW JERSEY, AND WEST VIRGINIA**

On most of the soils in Ohio, Indiana, Illinois, Iowa, Missouri, Kentucky, Pennsylvania, northern New Jersey, and West Virginia, lime, inoculation, and some sort of fertilizer treatment are essential for the best growth of alfalfa. Discussions regarding these features will be found on pages 9-13.

Where the land is well suited to alfalfa the seed is commonly sown in the early spring with a small grain sown at about one-half the normal rate, or occasionally in winter wheat or rye. Better stands are assured under the former practice. If the nurse crop gives evidence of injuring the alfalfa seedlings, it should be cut for hay. Early canning peas have also been successfully used as a nurse crop. Good results are often obtained if the seed is sown after an early crop of sweet corn, potatoes, or truck vegetable. Such land requires little preparation for alfalfa, provided it has been well cultivated. Small-grain crops usually mature early enough for late-summer sowings of alfalfa, but there is very likely to be a deficiency in the soil moisture at this time, owing to the demands of the previous crop. An early crop of red clover may also be taken off soon enough to get the land into shape for alfalfa the same year. Such land will require considerable preparation, as it needs to be plowed and thoroughly worked before alfalfa can be safely sown.

The quantity of seed required varies with the perfection of the seedbed, the character of the soil, and the condition of the weather at sowing time. Under favorable conditions about 8 to 10 pounds per acre has proved sufficient, although most of the experiment stations in these States recommend 10 to 15 pounds.

If the weather is favorable and the soil in good condition and free from weeds, it does not seem to make much difference when the seed is sown, as long as there is sufficient time for the plants to become well established before winter starts in. During midsummer, however, the weather is usually too hot and the soil too dry to insure successful germination and growth of seedlings. It is not advisable to sow much later than the first of September.

THE SOUTHEASTERN STATES AND THE GULF COAST

The soils in the Southeastern States and the Gulf coast region, with few exceptions, are not naturally well suited to the production of alfalfa, and careful attention must be given to preparing the land for the crop. Consideration should be given to liming, inoculation, and fertilizing, which are discussed on pages 9-13. Weeds are especially troublesome in this region, and for this reason alfalfa should be preceded for 1 or 2 years with crops that are cleanly cultivated or with such a crop as cowpeas, which chokes out weeds. Corn and cotton are good preparatory crops. Early truck and potato crops furnish excellent opportunities for destroying weeds and may generally be taken off the land in time for sowing alfalfa. These crops leave the land in such shape that plowing is not necessary. Red or

crimson clover or rye and vetch can be cut up with a disk, then turned under, and the land prepared for the late-summer or early-fall sowing of alfalfa. A common practice in the southern part of the region is to sow winter grain after a crop of corn or cotton has been removed. The grain is harvested in the spring and the land plowed and sowed to cowpeas as soon as possible. In the latter part of the summer the cowpeas are cut up with a disk, and the land is plowed and prepared for sowing by the latter part of September or early October. Farther north the same system may be used, but the crop of cowpeas should be cut for hay and the land disked and harrowed for alfalfa. It is not advisable to plow under cowpeas as far north as Virginia, as there is not time for them to decompose and the land to settle before alfalfa is sown. In sections where considerable silage corn is produced, successful stands are sometimes obtained from sowing after the corn is removed.

In this region alfalfa is generally sown without a nurse crop at the rate of 15 to 25 pounds per acre. In the Piedmont sections, on the Mississippi Delta, and on the prairie limestone soils of Alabama and Mississippi good stands are secured with 15 to 20 pounds, but on the Coastal Plains, where the soils are sandy and weeds troublesome, 25 pounds per acre is usually recommended.

In the northern part of the region under consideration sowings made about the middle of August have given the best results on an average. In the South Atlantic and Gulf States the date of sowing may be delayed with safety until the middle of October, and when weather conditions are especially favorable successful stands are sometimes obtained from sowings made as late as the first of November, although they are not recommended. Early spring sowings—that is, in March—are sometimes successful in the extreme South.

SEMIARID CONDITIONS

Alfalfa is grown extensively in parts of the West where rainfall is limited and where water is not available for irrigation. In this region soil-moisture conditions are usually most favorable in the spring, and in the North it has generally been considered the best practice to sow as early in the spring as the ground can be put in shape; but recent experiments indicate that in some sections at least weeds are less troublesome if sowing is delayed until the 1st to the 15th of May. This gives opportunity to work up the seedbed two or three times, thus destroying many of the weeds. If sowing is delayed until the weather is hot and dry, the plants may not become well enough established to survive the winter. From Kansas southward seed may be sown either in the spring or early fall. Moisture conditions usually are most favorable in the spring, but weeds are likely to prove more troublesome when seed is sown at this time. For this reason many growers prefer to keep the land cleanly cultivated during the summer and sow the seed in the late summer or early fall.

Preparation for alfalfa should begin somewhat in advance, to insure sufficient moisture for the young seedlings. If the seed is to be sown in the spring the land should be summer-fallowed the previous year or devoted to some cultivated crop, such as corn, to assist in freeing it of weeds and to conserve moisture. Except on heavy

soils it will not be necessary to plow again, but where plowing seems advisable it should be done in the fall and the land disked and harrowed as soon as it is in condition to be worked the following spring. Land to be sown in late summer or early fall should be plowed the previous fall and kept cultivated throughout the spring and early summer.

The use of a nurse crop is not recommended under dry-land conditions, as it draws too heavily on the rather limited moisture supply. However, good stands are frequently obtained with one-third or one-half the normal rate of sowing of some small-grain crop, particularly where it is cut early for hay. Good results are also obtained from the use of flax as a nurse crop.

Over most of the dry-farming area less seed is required than is advised under humid conditions or under irrigation, partly owing to the fact that weeds are less troublesome. Ordinarily, from 6 to 8 pounds of seed per acre is ample. Good stands have been obtained with 2 to 4 pounds, but such light rates cannot be recommended for general practice.

SANDY SOILS

In the Eastern States alfalfa usually does not survive long on very sandy soils, although fairly good yields may be obtained for 2 or 3 years where liberal applications of stable manure are made prior to sowing the seed. West of the Mississippi River such soils, if not too sandy, usually will grow alfalfa successfully after the plants are once well-established. However, it is often difficult to start the crop on soils that are so light in texture that they drift badly, as the young plants are likely to be cut off by the sand unless special precautions are taken. This may be avoided by applying a light top dressing of straw or coarse manure just after sowing. Another method that has proved satisfactory is to scatter a thin layer of wild hay or straw from an old stack bottom over the land immediately after the seed has been sown. The field is then gone over with a weighted disk set straight. This cuts the hay into the ground and leaves it standing over the field, much like stubble. Good results are also had if the alfalfa is drilled into high-cut stubble of sorghum or millet. Where cornland is used and the field is in good shape, it may be prepared by disking down the stalks early in the spring and leaving the soil rough until time for sowing. Alfalfa seed may also be sown with about a peck per acre of rye, barley, or some other small-grain crop that will make rapid growth and protect the young alfalfa seedlings. Unless there is danger of injury from drifting soil the nurse crop should be avoided, as it is likely to draw so heavily on the soil moisture as to injure the alfalfa.

The rate of sowing generally advised is from 10 to 15 pounds per acre. The press drill gives the best results, but if not available, the seed may be sown broadcast and the land harrowed and then rolled to get the seed into contact with the moist soil and hasten germination. After rolling the soil, it is best to harrow it lightly so as to reduce the possibility of the formation of a crust on the surface.

SOWING ALFALFA UNDER IRRIGATION

In preparing irrigated land for alfalfa the first step is to break it deeply and then level it if necessary. Plowing should be done several weeks in advance of sowing so that the soil may be properly com-

pacted by the use of a heavily loaded disk, a roller, or some other suitable implement. Ordinarily it is best to irrigate the land just prior to sowing the seed; and, as soon as it has dried out sufficiently, the surface should be worked up into a fine mellow seedbed. If possible, further irrigation should be avoided until the plants have developed three or four leaves. Good stands are sometimes obtained where the seed is "irrigated up," but the practice is not recommended, particularly on heavy soils, as the surface often becomes so crusted that the young plants are unable to break through.

For ordinary conditions the rate of sowing should be about 15 pounds per acre, although a smaller quantity may give good stands under ideal conditions. Generally speaking, somewhat less seed seems to be required in the northern irrigated districts than farther south, probably because weeds are somewhat less troublesome. The time of sowing depends upon frost conditions, but should be early enough to allow the plants to become well established before cold weather. In the extreme Northern States the best stands are obtained where the seed is sown as early in the spring as is possible to get the land in condition. Ordinarily, at this time of year the soil contains considerable moisture as a result of winter precipitation, and irrigation prior to sowing is not essential. Another advantage of early-spring sowing is that during cool weather the soil does not dry out very rapidly and the plants have an opportunity to become well established before irrigation is necessary. In Montana and the Dakotas the latter part of April or early in May is about the earliest date that alfalfa can be sown safely. Under favorable conditions in these States good stands have been obtained where seed was sown on disked grain stubble in the late summer. In the extreme Southwest good stands may be obtained from sowing almost any time between October 1 and April 15, although the December and January sowings are occasionally injured by cold weather. October is the most favorable month, but where it is impossible to get the land in shape in the fall, February and March sowings usually give satisfactory results. The hot summer months constitute the most trying period.

As a rule, the best stands are obtained where alfalfa is sown alone. In the Northern States, however, a nurse crop is not particularly objectionable, provided it is sown at about one-half or one-third of the usual rate. In the Southwest it is best to avoid the use of a nurse crop.

TREATMENT OF STANDS

Late-summer or fall-sown alfalfa requires no treatment that season. Even though the plants make considerable growth before being checked by frost, they should not be cut. Where alfalfa is sown in the spring, weeds usually appear in abundance, and the important question is whether it is better for the alfalfa if the weeds are cut back or allowed to grow. There is a generally prevailing theory that the frequent cutting of young plants forces them to stool out and increases root growth, but carefully controlled experiments have demonstrated quite clearly that such treatment actually checks root development. Even where weeds are very rank, such evidence as is available indicates that it is better to delay clipping until the young alfalfa plants have reached the proper stage, that is, until

they are in bloom. Although the earlier clipping may check the weed growth to some extent, it also weakens the alfalfa seedlings and lessens their ability to compete with the weeds.

When the field is cut, the growth should be removed if there is any danger of smothering the seedlings; otherwise it may be left on the ground as a mulch. In the northern Great Plains and intermountain region weeds in alfalfa have been allowed to go unclipped throughout the first season, the subsequent stand of alfalfa benefiting by such treatment. Where this is done it is advisable to get rid of the dead growth early in the spring. In the North, where only hardy alfalfas are grown, this has been accomplished by burning over the fields, but the more tender alfalfas are sometimes injured by such treatment. Where it is not safe or convenient to burn off the fields the dead growth may be raked up and hauled off. In the South and Southwest it is often possible to procure two or three cuttings of hay the first year from spring sowings, and where this is the case the recommendations made above do not apply.

Alfalfa should not be pastured until after the first year, and should never be pastured closely as the grazing down of the crowns often results in killing of the plants. Cattle should never be allowed access to a field when the ground is wet or frozen. Where the alfalfa is sown in the spring with a small-grain companion crop, grazing for a few days in a dry season reduces the growth of the companion crop and usually results in better stands of alfalfa.

Attempts to improve poor stands by reseeding alfalfa generally prove futile. It is better to plow up unsatisfactory stands and reseed, after planting the land to some cultivated crop for a year or two. It is possible, however, to seed timothy in thin stands of alfalfa and thus prolong the usefulness of the meadow. After the last cutting of alfalfa has been removed, the seedbed should be prepared by means of an alfalfa harrow or some similar implement, and the timothy seed should be sown broadcast or drilled. Where adapted, orchard grass may be used instead of timothy.

In the East a top dressing of well-rotted stable manure applied in the late fall or in winter not only furnishes some protection but in most cases also increases the yield the following season. If stable manure is not available, an application of 300 to 500 pounds of 0-14-6 fertilizer per acre in the spring is of considerable assistance in maintaining the vigor of the stand.

CULTIVATING ALFALFA

For many years the disking or harrowing of alfalfa fields has been advocated on the theory that it increases the yield and prolongs the life of the stand. Although some form of cultivation appears advisable under certain special conditions, any general statement to the effect that alfalfa fields are always benefited by such treatment is not borne out by actual experience. Where irrigation water leaves thick deposits of silt on the field, where the soil in irrigated fields has been compacted by cattle grazing on the alfalfa, or where attempts are to be made to improve the productivity by fertilizing or by sowing grass in thin stands, some sort of cultivation may be essential. There is little or no advantage, however, in cultivating broadcast alfalfa as long as the stand is satisfactory and the plants are making

good growth. Extensive experiments have shown that under such conditions the increase in yields, if any, is not sufficient to pay the additional cost of producing the crop.

In seed-producing areas, however, alfalfa is often cultivated rather severely in order to destroy the weeds and thin the stands of alfalfa, as thin stands usually produce better yields of seed.

The best implement for cultivating alfalfa is the so-called alfalfa harrow, which is a modified form of the spring-tooth harrow (fig. 5). This implement loosens the soil without seriously injuring the plants. The spike-tooth harrow will loosen up the lighter textured soils, but is of little benefit on the heavy soils. Experience has shown that in most cases the use of the disk harrow is actually injurious, as any implement that has a tendency to split the crowns renders the plant more susceptible to certain diseases.

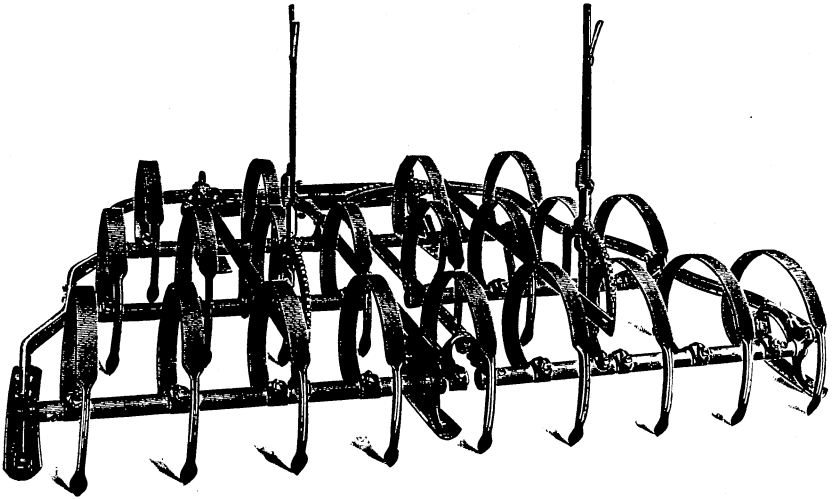


FIGURE 5.—Type of harrow commonly used in cultivating broadcast alfalfa.

The best time for cultivating a field of alfalfa will depend upon the object to be gained. Ordinarily it should be early in the spring or immediately after any one of the cuttings. Alfalfa should never be cultivated the first year after sowing as the plants are so small that they are easily pulled out and killed.

MAKING ALFALFA HAY

Most of the alfalfa grown in this country is cut for hay. The number of cuttings obtained depends upon climatic conditions, the soil, and the variety of alfalfa and varies from 8 or sometimes more in the far Southwest to 2 and sometimes only 1 in the North and semi-arid sections. From 30 to 40 days are required to produce a hay crop.

The stage of growth at which alfalfa is cut has a marked effect on the feeding value of the hay, the life of the stand, and yield. Hay of the highest feeding value results from early cutting, owing to the greater proportion of leaves, which contain twice as much protein as the stems. Continued cutting as early as the bud stage, however, has been shown repeatedly to shorten the life of a stand very

materially under most conditions. Stands survive longer and yields often are larger if harvesting is delayed until the plants are in full bloom, but this is at the expense of the feeding value of the hay.

Recent experiments indicate that under certain conditions, at least, the first or the first and second growth may be removed at the bud or early-bloom stage without shortening the life of the stand provided one or more of the later cuttings are delayed until full bloom. By following this practice a better quality of hay is obtained from the early cuttings, which are generally rank and coarse. Whether one or more cuttings are removed at the early stage will of course vary with the number of crops obtained during the year. In the East alfalfa blooms very sparingly when the season is too wet or too dry; therefore, it is difficult to determine the stage of maturity by the flowers. The growth of the basal shoots, often suggested as a guide in determining the stage at which alfalfa should be cut, is even more unsatisfactory. When alfalfa blooms very sparingly the best guide for the experienced alfalfa grower is the color of the field. Alfalfa should be cut when it begins to take on a yellowish cast and the general appearance indicates that vegetative growth is slowing up or stopping entirely. More detailed information on making alfalfa hay and on the uses of alfalfa, including feeding of the hay, pasturing, silage, and alfalfa meal, may be found in Farmers' Bulletin 1839, *The Uses of Alfalfa*.

SEED PRODUCTION

Alfalfa seed production is most dependable where the climate is relatively dry, as in the arid and semiarid districts of the West. It is under such conditions that the greater part of the seed has been produced in the United States. During the past few years considerable seed has been obtained in the Middle West, particularly in northern Wisconsin, Minnesota, and Michigan, but the production in this part of the United States is rather erratic, being considerable in abnormally dry seasons and relatively unimportant in wet seasons that favor rank vegetative growth.

As hot, dry weather favors seed setting, it is customary to save for seed the crop that matures during the hottest and driest part of the summer. Over much of the country this is the second crop, but south of Kansas it may be the third crop. In the extreme North the season is usually so short that it is necessary to leave the first growth for seed. For a short time in the spring some growers pasture fields that are to be devoted to seed production.

For a seed crop, alfalfa should be cut when two-thirds to three-fourths of the pods have turned brown. The crop may be harvested with a mower having a bunching attachment or with a binder having the tying attachment removed. This leaves the alfalfa in convenient forkfuls and reduces shattering in handling. Where possible, alfalfa is threshed from the field, but in some cases it is necessary to stack it. An alfalfa huller is the most satisfactory thresher, although the ordinary grain thresher equipped with alfalfa sieves and with the concaves screwed down does satisfactory work. The average yield of seed per acre runs from 2 to 4 bushels.

Total production of alfalfa seed in the United States during the last 5 years has ranged from approximately 53,000,000 pounds in

1936 to 81,000,000 in 1939. For several years prior to the fiscal year 1937, importations of alfalfa seed were relatively small. During the past 4 fiscal years, however, annual importations have varied from 3,263,600 pounds in 1939 to 4,589,600 pounds in 1938. For the most part, these importations have come from Canada, but they include also some seed of Argentine, South African, and French origin.

BREAKING ALFALFA SOD

Farmers often complain of the difficulty of breaking up and destroying a stand of alfalfa, but under most conditions this need not offer any serious objection to the crop provided the necessary equipment is at hand, that is, strong horses or a tractor and a sharp plow. The plow should be in good condition when it enters the field, and the operator should carry a file to keep it sharp. It is, of course, more difficult to keep the plow in condition in gravelly or stony soil.

The furrow slice should be 2 inches less in width than the plow will turn. This is to prevent any of the large roots from slipping by uncut. Sometimes the plows are provided with a knife attachment to the landside to cut the roots near the outer edge of the next furrow. The most successful practice is to plow shallow in the fall and deep the following spring. If only one plowing is practicable, this should be rather shallow. If plowed too deeply the roots frequently retain enough life to start again. Ordinarily it is better to leave the furrow slice to dry out some time before cultivating, as this assists in killing the roots.

WEEDS

In most of the United States weeds constitute the worst enemy of alfalfa. Dodder, a threadlike yellow twining plant, which lives as a parasite on plants, is very objectionable in seed-producing districts, as there is little or no market for alfalfa seed that carries seeds of dodder with it, and the two seeds are very difficult to separate. Dodder seldom gives much trouble in fields that are devoted entirely to the production of hay. Other troublesome weeds are Kentucky bluegrass and quackgrass in the northeastern one-fourth of the United States; crabgrass and Bermuda grass in the Central and Southern States; cheat (*Bromus tectorum*) and foxtail, or wild millet, in the Middle West and the Great Plains; and whitetop, field peppergrass, chickweed, and yellow rocket in the Middle West and the East. In the irrigated sections of the West the wild barleys, also known as foxtail and squirreltail grass (*Hordeum* spp.), are decidedly troublesome, as the beards ruin the first crop of hay for feeding unless it is cut very early. Where weeds are troublesome in the West, wheat is sometimes drilled in the alfalfa in the fall, and as it comes on early, the growth of the weeds is checked. The first cutting of hay the following spring consists of a mixture of alfalfa and wheat. Cultivation of established stands of alfalfa may help to hold the weeds in check, but unless done with considerable care the alfalfa may be injured. The most satisfactory way to control weeds is to make the conditions so favorable for alfalfa that they are smothered out. When they become abundant it is better to plow the field rather than attempt to get rid of them by cultivation.

DISEASES

The most destructive alfalfa diseases in the United States include bacterial wilt (*Phytomonas insidiosa* (McC.) Bergey et al.); root rot (*Phymatotrichum omnivorum* (Shear) Duggar); crown wart (*Urophlyctis alfalfae* (Lagh.) Magn.); leaf spot (*Pseudopeziza medicaginis* (Lib.) Sacc.); yellow leaf blotch (*Pyrenopeziza medicaginis* Fekl.); alfalfa dwarf (virus); rust (*Uromyces striatus* Schroet.); and blackstem disease (*Ascochyta imperfecta* Peck.).

Bacterial wilt is regarded as the most serious disease attacking alfalfa at the present time. It is quite generally distributed but is especially destructive in some of the best alfalfa districts of the Middle West and West. It is much less prevalent in the extreme East. Where the disease is serious, stands of alfalfa seldom survive more than 2 or 3 years. The only known means of controlling the disease is to use resistant alfalfas, such as Turkistan, Hardistan, Orestan, and Ladak. New wilt-resistant alfalfa varieties are being developed, but seed of these new varieties is not yet available for distribution.

Root rot results from a fungus parasite upon the roots of alfalfa that causes the plants to die out in well-defined, usually circular areas, which gradually increase in size. It is the disease that attacks cotton and other taprooted plants and occurs from eastern Texas to southern California. Land on which the root rot occurs should be planted to fibrous-rooted crops, such as corn, sorghum, or some small grains, for several years until the fungus disappears.

Crown wart has been observed on the prairie limestone soils of Mississippi and in many of the States west of the Mississippi River, but it occurs in greatest abundance in California. The disease is characterized by the appearance of galls on the crown at the base of the stems. These galls, which are caused by a fungus, are much warted externally and vary in size from one-eighth to 3 or 4 inches in diameter. Affected plants are seldom killed outright; but growth is checked and the plants weakened, and smaller yields result. If the disease becomes serious, the land should be plowed and put into some other crop until the gall fungus is eliminated.

Leaf spot is a fungus disease that is very common where alfalfa is grown, and it may develop under all conditions of soil and weather. It is more destructive in humid sections than in dry sections. The disease is characterized by small brown spots about the size of a pinhead occurring on both sides of the leaves. Badly affected leaves turn yellow and drop off, thus reducing the yield and feeding value of the hay (fig. 6). If the field becomes very badly infected with the disease it is recommended that the crop be cut and removed.

Yellow leaf blotch is also a fungus disease that is common in all large alfalfa-growing regions of the United States. The disease attacks the leaves and is characterized by long yellow blotches sprinkled with minute brown dots. Where this blotch is serious it is best to cut the crop.

Alfalfa dwarf is a virus disease, the symptoms of which resemble bacterial wilt. This disease is very serious in parts of southern California, particularly south of the Tehachapi Mountains, and may destroy a stand in 2 or 3 years.

Rust is quite prevalent on alfalfa during some seasons. Where abundant it tends to check growth and to cause shedding of the leaves. When such a condition develops the alfalfa should be cut.

Blackstem is widespread but is most severe in the Southeast and the West. It occurs chiefly in the early spring, and it is particularly severe following open winters and during long, wet springs. The disease is characterized by large irregular brownish or blackish lesions that occur on the leaves and petioles as well as on the stems. No control is known.

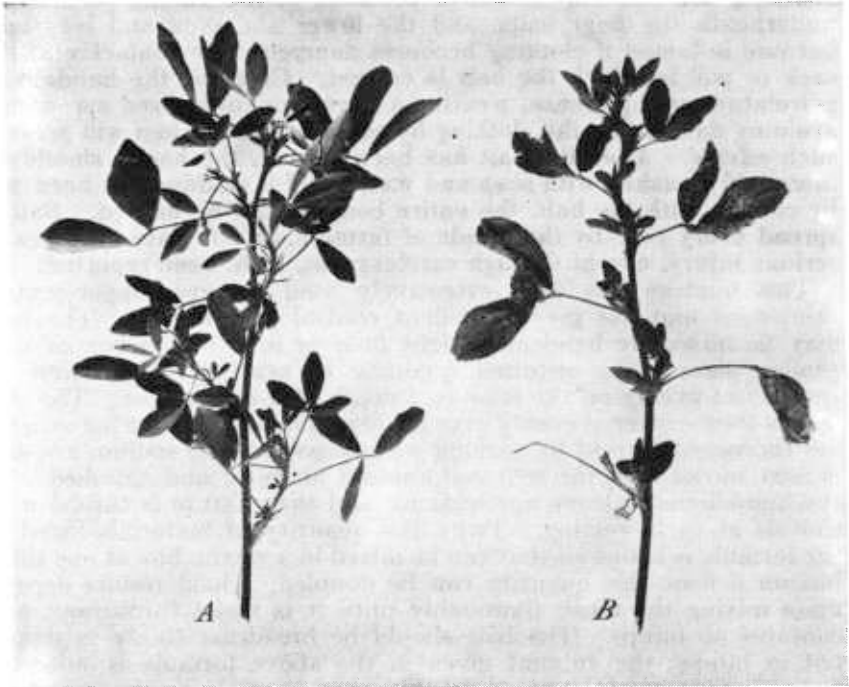


FIGURE 6.—(A) Healthy shoot of alfalfa, compared with (B) a shoot attacked by leaf spot caused by *Pseudopeziza medicaginis* (Lib.) Sacc. The abundant spotting of the leaves and the defoliation that results from severe infections are illustrated by the diseased shoot.

INSECTS ¹

Grasshoppers probably do more damage to alfalfa than any other insect. They occur in all parts of the country but are most often destructive in arid and semiarid regions. The most effective means of control is the use of poisoned bait. The formula recommended for general use is as follows:

Mill-run bran, mixed feed, or shorts.....	25 pounds.
Sawdust (3 times bulk of mill-run bran).....	3½ bushels.
Liquid sodium arsenite (32 percent arsenious oxide).....	½ gallon.
Water.....	10-12 gallons.

¹ Contribution of the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture.

Sodium arsenite is poisonous and must be handled carefully. It should not be put into any vessel that is used for any other purpose. It is recommended that only quantities sufficient for immediate use be purchased so that the necessity for storing may be avoided. This mixture is poisonous to animals as well as human beings, and great care must be taken to clean places where the bait has been mixed, as well as containers used in spreading. Clothing worn during these operations should be taken off immediately after the job is finished and washed before it is used again. Great care should be taken to avoid carrying particles to the mouth with the hands. Mixing and handling the bait may result in irritation of the hands, particularly underneath the fingernails, and the lower abdomen and legs may become inflamed if clothing becomes dampened by contact with the sack or pail in which the bait is carried. Greasing the hands with petrolatum or cup grease, wearing a canvas or rubberized apron, and avoiding dampening the clothing by contact with the bait will prevent such effects. After the bait has been spread, the hands should be thoroughly washed with soap and water, and if clothing has been wet by contact with the bait, the entire body should be bathed. Bait is spread every year by thousands of farmers, and to date no cases of serious injury, except through carelessness, have been reported.

This mixture has been extensively used in grasshopper-control campaigns and has given excellent control at low cost. The bait may be mixed by hand on a tight floor or in a wagon box or in a similar place. The required quantity of sawdust should first be spread out evenly on the floor to a depth of 6 to 8 inches. The mill feed is then scattered evenly over the sawdust, and the two ingredients are thoroughly mixed by turning with shovels. The sodium arsenite is next mixed with the required amount of water and splashed over the ingredients in three applications, and the mixture is turned with shovels at each wetting. Twice the quantity of materials listed in the formula is about all that can be mixed in a wagon box at one time, but on a floor this quantity can be doubled. Good results depend upon mixing the mash thoroughly until it is moist throughout and contains no lumps. The bait should be broadcast thinly in flakes, not in lumps; the amount given in the above formula is sufficient for about 10 acres. Spread in this way, there is no danger of its poisoning farm animals, but precautions should be taken in handling the poison and the mixed bait in bulk to avoid all danger of poisoning persons or livestock. As animals may accidentally gain access to poisoned bait stored in bulk or disposed by burial in the ground after the baiting season is over, it is preferable to scatter any surplus bait thinly in the fields in the same manner as when grasshoppers are present, instead of storing it. More detailed directions are contained in Farmers' Bulletin 1828, Grasshoppers and Their Control.

The alfalfa weevil is quite destructive in parts of the West. It appeared first in Utah in 1904 and subsequently spread to Nevada, Idaho, and Wyoming, western and northern Colorado, southwestern Nebraska, southern Montana, southwestern South Dakota, eastern and southern Oregon, the San Francisco Bay district, and the north-eastern portion of California.

The insect in both larval and adult stages feeds upon the green leaves and tender buds of the alfalfa plant; if numerous, it inflicts severe damage. The most effective and economical means of control

is early and clean cutting of the first crop, so that the immature stages of the weevil are killed by starvation and exposure to heat immediately following removal of the crop. Control may also be accomplished through application of powdered calcium arsenate mixed with water to form a spray. The approved formula is 2 pounds of calcium arsenate to 100 gallons of water—the quantity to be applied as a spray to 1 acre of alfalfa. Calcium arsenate may be applied more easily as a dust instead of as a spray, but it is not so effective in this form. Application by dusting has been widely used, however, and if dusting equipment is available, satisfactory control may be obtained by this method. For details regarding dusting it is recommended that alfalfa growers apply to their State experiment stations.

Calcium arsenate is poisonous. If it is applied as a dust, full face-piece insecticide respirators should be worn, and the skin of the entire body protected. When calcium arsenate is applied as a liquid, the eyes should be protected by goggles having indirect ventilation, and all parts of the skin should be protected. Clothing worn while spraying or dusting should be thoroughly cleaned before being used again.

One of the most serious of alfalfa troubles is the yellowing of the plants as a result, at least in part, of the attacks of leafhoppers. Although these insects seldom kill plants outright, their attacks are doubtless responsible for material reductions in yields of alfalfa, particularly in the Eastern States. No economical method of control for these insects is yet available.

A number of other kinds of insects inflict more or less serious damage on alfalfa. The more important of these are: The alfalfa seed chalcid, garden webworm, clover root borer, clover root curculio, alfalfa aphid, alfalfa caterpillar, clover leaf weevil, various cutworms and army worms, the alfalfa looper, blister beetle, crane fly, harvester ant, three-cornered alfalfa hopper, stinkbug, and plant bugs of the genus *Lygus*. Information on the control of most of these insect pests may be obtained upon application to the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture.

RODENTS

The most troublesome animal pests encountered in growing a crop of alfalfa are gophers, ground squirrels, prairie dogs, and mice. They are especially troublesome in the western half of the country, where they eat the roots of the plants. Where irrigation waters are available these pests are controlled to some extent by drowning. Poisoning and trapping are the best means of holding them in check, but because of the danger attending the careless use of poisons it is suggested that the farmer get in touch with the county agricultural agent or a representative of the Fish and Wildlife Service, Department of the Interior, when these pests become troublesome.